Merrimack River Watershed Assessment

Lower Merrimack River

Zach Eichenwald, PE
Lauren Klonsky, PE
Gary Mercer, PE

December 20, 2018

CDM Smith

Outline

- Introductions
- Background and Review of Project and Objectives
- Study Results and Findings
  - Monitoring
  - Modeling
  - Assessment Outcomes
- Next Steps and Discussion

Introductions

- USACE
- CDM Smith
- Stakeholders
- Merrimack River communities

Background

Review of Phase III Project Objectives

- Evaluate river health and water quality from Manchester, NH to the Estuary
- Create a basin-scale model to:
  - Assess changes in river health and water quality
  - Evaluate impact of WQ management measures
  - Evaluate potential future conditions
- Provide scientific information to support decision-making on the river

Background

- Study area extends from Hooksett, NH to Newburyport, MA
- Drainage area ≈ 5000 mi^2
  - 75% NH, 25% MA
- 3 hydropower dams
  - Amoskeag (NH)
  - Pawtucket, Essex (MA)
- 11 wastewater treatment plants
- 11 major named tributaries

Merrimack River Watershed Study

2002 2004 2006 2008 2010 2012 2014 2016 2018

Phase I

USACE, Manchester and Nashua, NH, Lowell, GLSD, and Haverhill MA

2002-2006

Study Area: Hookset, NH to Atlantic Ocean

Water Quality Monitoring:
- Three dry weather and three wet weather events
- BOD, DO, bacteria, nutrients, chlorophyll-a, and others

Modeling:
- Developed Hydrological Simulation Program-Fortran (HSPF), Storm Water Management Model (SWMM), and Water Quality Analysis Simulation Program (WASP) models
- Calibrated and validated models to dry and wet weather data

Scenarios Evaluated (developed w/stakeholders):
- Primary focus on bacteria
- Evaluated controls on CSOs and nonpoint sources

Phase II

USACE and NHDES

2008-2018

Study Area: Lincoln, NH to NH/MA state line

Water Quality Monitoring:
- Impoundment studies
- Continuous DO and temperature monitoring, sediment oxygen demand, and nutrient flux monitoring
- Two low flow and 1 high flow sampling events
- BOD, DO, bacteria, nutrients, chlorophyll-a, and others

Modeling:
- Extended models to Lincoln, NH
- Updated and calibrated models to low and high flow data

Scenarios Evaluated (developed with Southern New Hampshire Planning Commission and stakeholders):
- Two groups of scenarios, 2013 and 2017 (Phase 3 updated model used for 2017 scenarios)
- Primary focus on DO and nutrients
- Examined controls on NPS, WWTPs, dams, and others

Phase III

USACE, Manchester and Nashua, NH, Lowell, GLSD, and Haverhill MA

2014-2018

Study Area: Hookset, NH to Atlantic Ocean

Water Quality Monitoring:
- Two dry weather and two wet weather events (one event started dry, then rained)
- BOD, DO, bacteria, nutrients, chlorophyll-a, and others

Modeling:
- Updated and validated models to dry and wet weather data

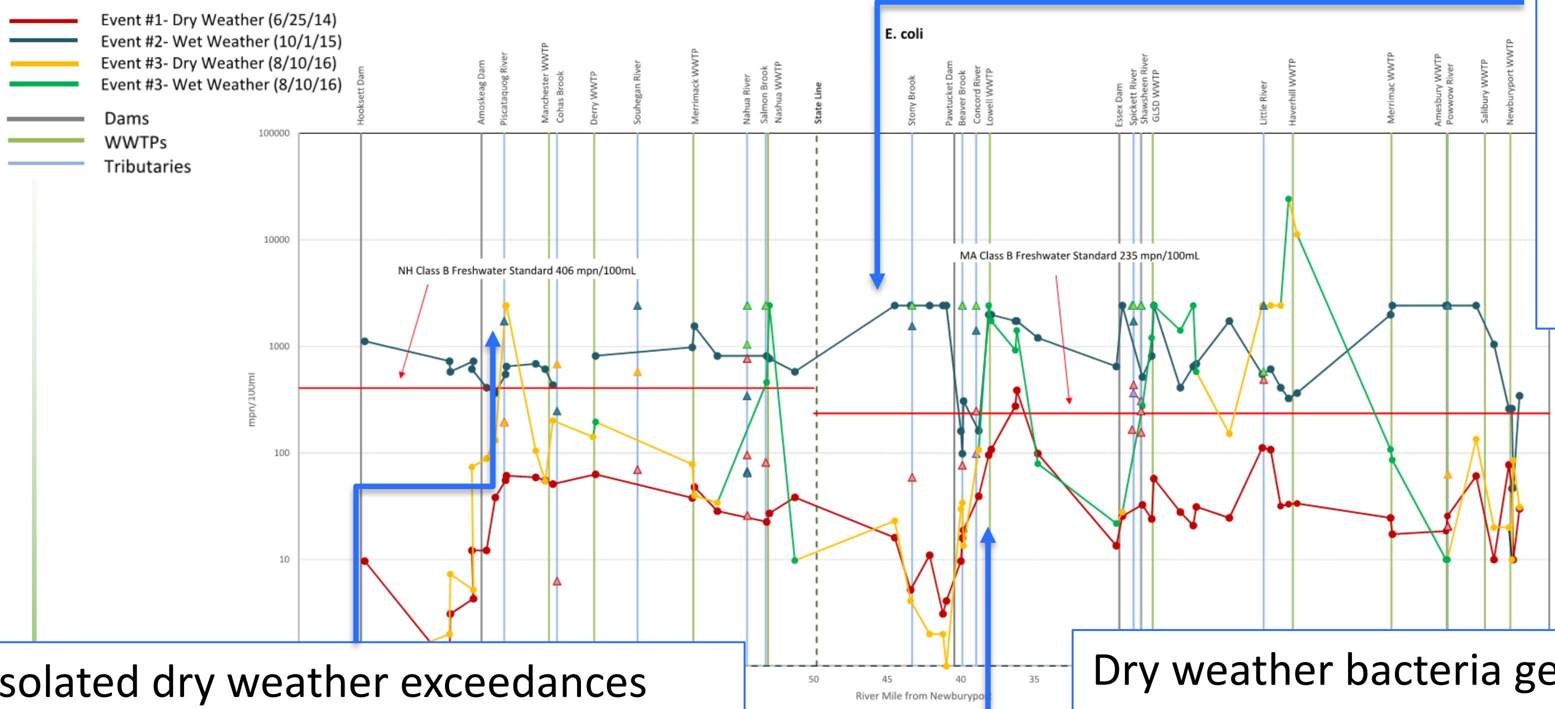
Scenarios Evaluated (developed w/ stakeholders):
- Focused on bacteria and nutrients
- Examined controls on WWTP for nutrients
- Examined controls on CSO and nonpoint sources for bacteria

Study Results and Findings

Study Methodology

- Results and conclusions are the culmination of 15 years of monitoring and assessment modeling
- Characterize existing conditions
  - Identify pollution sources
  - Comprehensive monitoring of instream water quality
- Estimate water quality improvements for various management strategies with computer models
  - CSO abatement
  - WWTP Technologies
  - Nonpoint source abatement
  - Blended management plan
- Compare costs and benefits of each plan (Phases I and III only)

Water Quality Monitoring: Bacteria



Wet weather bacteria generally exceed state criteria
→Cause likely combination of stormwater and CSO

Isolated dry weather exceedances occurred; source not clear from data

Dry weather bacteria generally meet state criteria and improved over Phase I monitoring data:
→IDDE and other programs successful

Water Quality Monitoring: Nutrients, Chl-a, DO

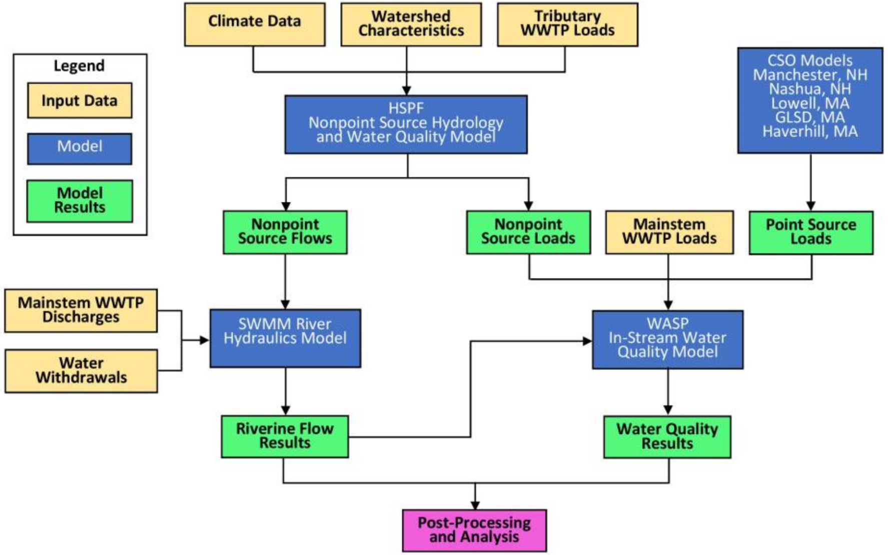
- No exceedances of state DO criteria
- Chlorophyll-a and TP occasionally exceed guidance values during low flow sampling in freshwater Merrimack River
- TN concentrations in estuary measured, but no guidance value on TN endpoints in Massachusetts Bay
  - No TN or nutrient-related impairments in estuarine Merrimack River on Massachusetts 303(d) list

Water Quality Monitoring: Next Steps

- Continue Clean Streams Initiative sampling
- Improve understanding of algae dynamics in Lower Merrimack
- Others?

Assessment Modeling

- Comprehensive hydrologic, hydraulic, and water quality modeling informed by monitoring program
- Use model to understand baseline condition and predict river response to:
  - Different hydrologic conditions, including potential future conditions
  - Future point and nonpoint source loads



- Model results evaluated against MA/NH CALM guidance and surface water quality standards

Key Findings: Bacteria Scenarios (LM Only)

- Compared to prior monitoring and analysis:
  - Significant dry weather bacteria reductions – reflects IDDE and other program work
  - Significant reduction in CSO activation frequency and volume
- Increased development in watershed → higher stormwater bacteria loads
- CSO reduction (to 3-month control) helps compliance with state criteria, but not only path forward

Key Findings: Nutrient Scenarios

- No predicted exceedances of state dissolved oxygen criteria
- TP and chlorophyll-a occasionally exceed NH & MA guidance values, but compliance with DO criteria suggest no current aquatic health risks
- Reducing point source TP concentrations provides the greatest reduction in chlorophyll-a concentrations, reducing the likelihood that chlorophyll-a exceeds guidance thresholds
- System is sensitive to temperature increases, and temperature increases have the potential to increase phytoplankton productivity

Key Findings: Nutrient Scenarios

- 3-month CSO control will have little impact on instream nutrient and chlorophyll-a levels
  - CSO nutrient load low relative to other point and nonpoint sources
  - CSOs occur during wet weather when residence time is short
- Pilot-scale MS4 / green infrastructure (GI) has significant implementation cost but very small reduction in TP/chlorophyll-a in mainstem Merrimack
  - Nonpoint source reduction may be important in tributaries
  - Other nonpoint source controls, such as fertilizer controls, pet waste education programs, or septic system repair may result in a more cost-effective reduction in TP/chlorophyll-a

Future Considerations for Modeling

- Use the Merrimack River Model as a tool to understand how the river will respond to future point/nonpoint source inputs
- Expand and build upon Lowell's model to improve understanding of spatial/temporal variability in bacteria, nutrients, and chlorophyll-a
- Improve understanding of nutrient dynamics in Massachusetts Bay to improve the representation of the Merrimack River estuary

Cost-Benefit Analysis

- Trade-off analysis to compare water quality benefits to planning-level implementation costs

Planning-Level Costs	Water Quality Benefits
Additional CSO control (3-month)	Attainment of bacteria standards (existing, new Mass proposed)
MS4 / GI Controls	
TP reduction to 1 mg/L	Days below 15 or 16 µg/L chlorophyll-a guidance values
TP reduction to 2 mg/L	

Cost Basis

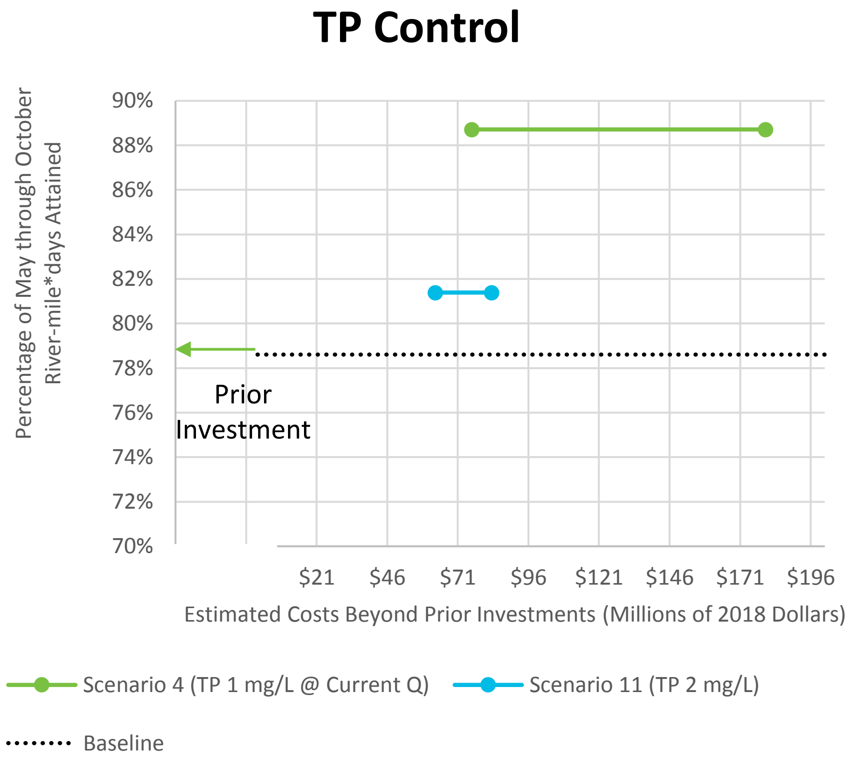
- All costs are <u>planning-level</u> only and do not take into consideration site-specific project needs and aggregated to a watershed level

Element	Cost Basis
Additional CSO control	Costs reported in latest LTCP or by municipality, escalated to 2018 dollars
MS4 / GI control	Range of unit costs based on EPA's Opti-Tool
WWTP TP removal	• Cost reported by municipality • Highest of estimated[1] chemical or biological phosphorus removal, including sludge disposal costs and engineering/construction contingency

[1] Estimated costs based on CDM Smith experience with capital and O&M costs from other New England construction projects

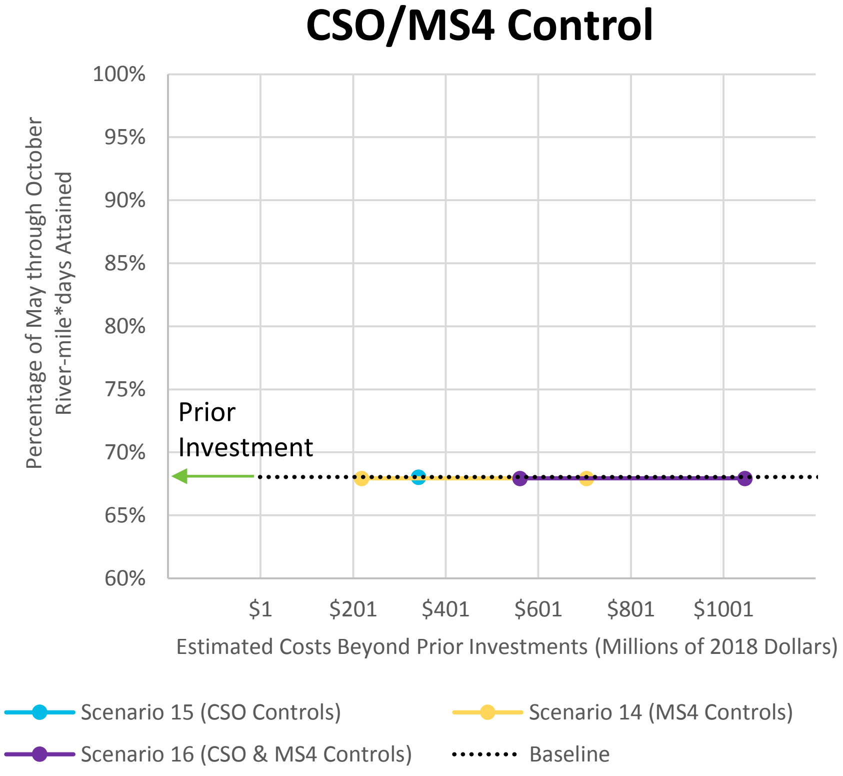
Chlorophyll-a Analysis: WWTP TP Control

- WWTP TP control shows largest improvement relative to guidance levels
- TP at 1 mg/L has greatest benefit above prior investment, but at the greatest cost
- TP at 2 mg/L has a lower relative benefit, but lower cost



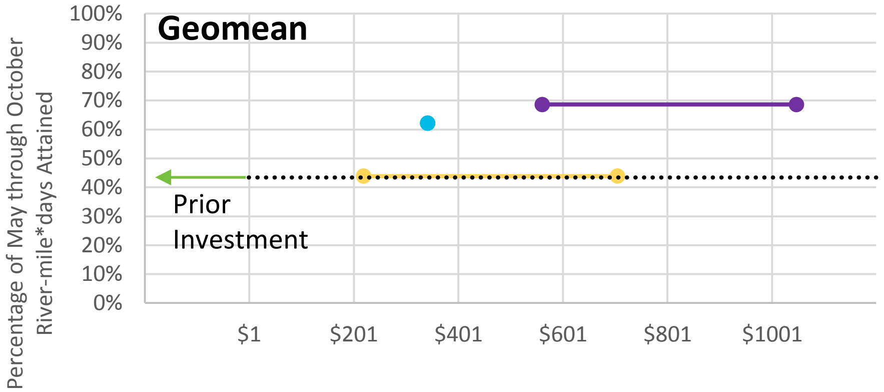
Chlorophyll-a Analysis: CSO and MS4 Control

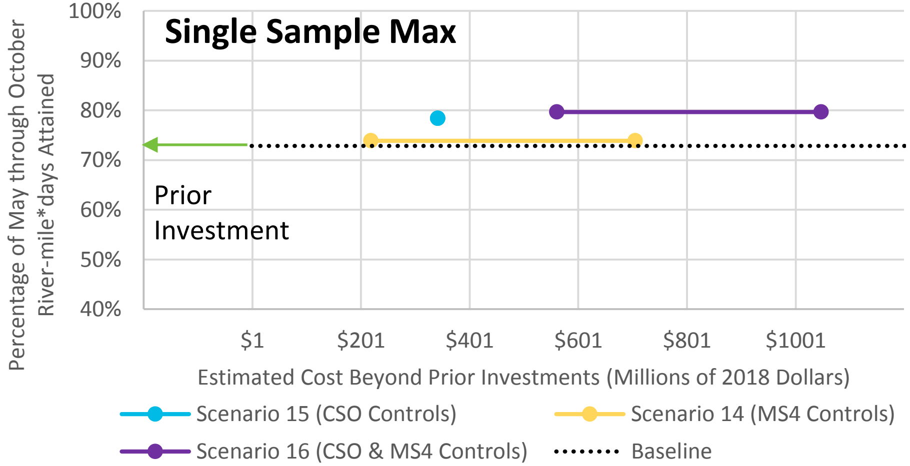
- CSO and MS4/ GI are relatively small TP load
- CSO and MS4 / GI controls yield little benefit at high cost
- Non-structural best management practices (BMPs) may result in cost-effective TP control at lower cost



Bacteria Analysis (Urban Areas Only)

- Full compliance with bacteria standards is not expected even with 3-month CSO control plus GI controls in MS4 areas
- CSO control more effective than GI alone
- GI implementation cost potentially high
- Modeled stormwater controls did not include non-structural BMPs that may be more cost effective
- Stormwater controls will likely improve compliance on tributaries





Assessment Outcomes

- Study conclusions based on the culmination of 15 years of monitoring and assessment modeling
- Water quality conditions are significantly improved over conditions in the near past
- Water quality is generally good, with no measured or modeled exceedances of DO criteria, and occasional exceedances of nutrient and chlorophyll-a guidance values
- Exceedances of bacteria criteria still occur, especially during wet weather
  - Causes include both CSO and stormwater, and controlling either source alone will not achieve compliance
- Adaptive management and integrated planning are necessary to focus investments in water quality infrastructure

Next Steps

Potential Next Steps

- Continue monitoring water quality
- Use the model as a tool to understand how the river will respond to future point/nonpoint source contributions


Discussion